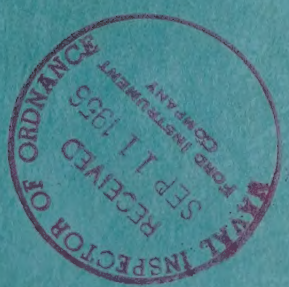
INSTRUCTION MANUAL NO. E-949A

for the FAIRCHILD

TRANSISTOR DYNAMIC ANALYZER



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MA30025

ENGINE AND AIRPLANE CORPORATION
FAIRCHILD
Guided Missiles Division
WYANDANCH, L. I., N. Y.

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TRANSISTOR DYNAMIC ANALYZER

The Fairchild Transistor Dynamic Analyzer, a single, compact instrument, provides the necessary circuitry to present 5 separate transistor characteristics on a cathode ray oscilloscope. These characteristics include:

1. Collector - (grounded base); V_c vs. I_c, I_e as parameter
2. Transfer; V_e vs. I_c, I_e as parameter
3. Emitter; V_e vs. I_e, V_c as parameter
4. Alpha; α vs. I_e, V_c as parameter
5. Collector - (grounded emitter); V_c vs. I_c, I_b as parameter

All curves are swept with a 60 ~ sine wave, and the trace is swept out and back in order to detect possible transistor hysteresis or instrument malfunction.

The outputs of the Transistor Dynamic Analyzer are from cathode followers, but due to the small signals involved during some measurements, it may be desirable to use shielded leads to the oscilloscope.

A sensitive, d-c cathode ray oscilloscope, such as the Dumont 304, must be used in conjunction with this instrument.*

*The oscilloscope should be modified by reversing the connections to the horizontal deflection plates so that a positive voltage will give a deflection to the left.

The Analyzer is supplied with a transistor socket assembly which plugs directly into the panel. Two sockets are mounted in this unit, a special 3 contact socket for the Bell Labs. type of transistor case and a 5 pin, sub-miniature in-line socket which will handle transistors having pigtails or in-line wire pins. The asymmetrical based units can also be mounted in this socket since the 3 inner pins are connected together.

Preparatory to making any measurements, the following procedure must be followed:

PRELIMINARY ADJUSTMENTS

Connect two shielded cables from the VER and HOR outputs of the analyzer to the inputs of the cathode ray oscilloscope. The oscilloscope should be switched to the d-c amplifiers in both channels.

Adjust the two ZERO SET controls located at the back of the chassis so that no deflection occurs when the cables are plugged into the oscilloscope. These controls zero the d-c output voltage of the two cathode followers.

CALIBRATION

A simplified schematic of the calibration circuit is shown in Fig. 1. It consists of two sets of biased diodes which are switched in four combinations by the CALIBRATE AXES switch. A voltage divider is used as a multiplier for the continuously variable diode biasing. Select the quadrant axes to be used by set-

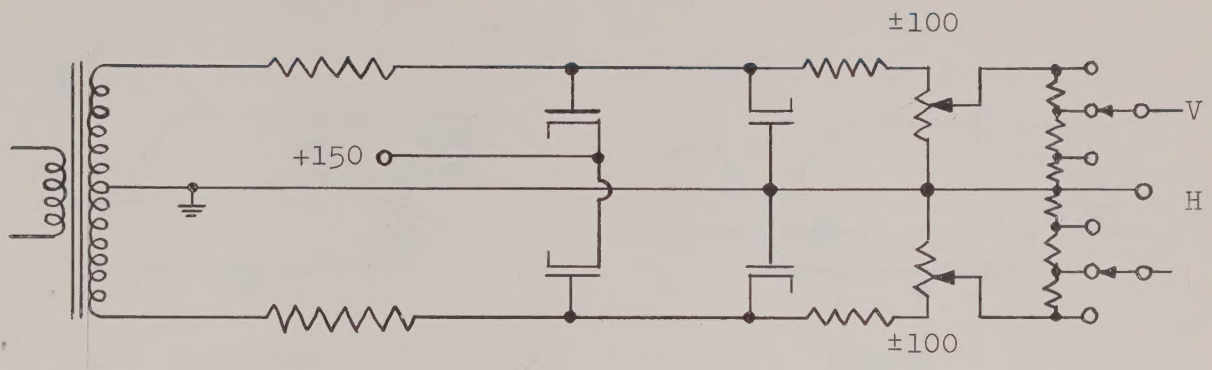

Figure 1

ting the CALIBRATE AXES switch to the appropriate position. These axes are particularly helpful when photographing a family of curves as they can be superimposed in the photograph. Depress the CALIBRATE lever switch and adjust the VERTICAL CALIBRATION and HORIZONTAL CALIBRATION according to the full scale deflections desired. When the graduated scale knob is rotated to its full scale clockwise position, the voltage from zero to peak will be 1, 10, or 100 volts according to the position of the adjoining switch. Although the scales are calibrated in volts, the horizontal trace will also read directly in milliamperes, since all currents are measured across a 1000-ohm resistor. The gain controls on the oscilloscope are then adjusted for a convenient trace length, such as 10 volts/inch, or 1 ma./inch, etc.

The C.R.O. is now calibrated and quantitative measurements may be taken.

COLLECTOR CHARACTERISTIC - (grounded base) Collector voltage vs. collector current.

A simplified schematic of this circuit is shown in Fig. 2. The emitter is biased positive or negative according to the transistor type from a 150 volt regulated source. The emitter bias current is varied by means of three front panel controls: UNIT STEPS, DECADE STEPS, BIAS CONTROL. The collector is fed through a diode from a 1:1 isolation transformer which is in turn driven by a variable auto-transformer; AC VOLTAGE CONTROL. The voltage is taken at the collector and the current from across a 1000 Ω resistor in the return circuit.

The slope of each curve thus taken is the collector resistance (r_c) at that point.

Operation

Switch the FUNCTION switch to the COL position, and set the DECADE STEPS switch to any position other than -.02 (this position is reserved for the grounded emitter test). This determines the magnitude of each step in the family when the UNIT STEPS switch is rotated. For example, if the DECADE STEPS switch is set to 0.2, the emitter current can be varied in ten 0.2 ma. steps from 0 to 2 ma. If intermediate positions are desired, set the UNIT STEPS Control to the position marked VAR., and

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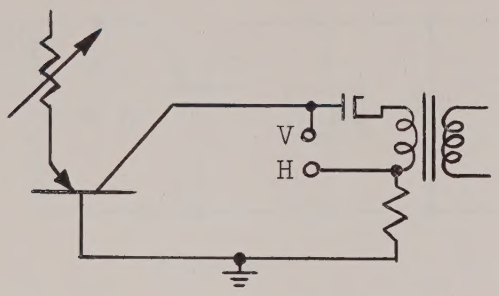

Figure 2

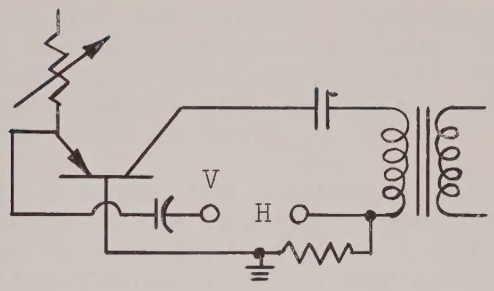

Figure 3

rotate the BIAS CONTROL. The DECADE STEPS Switch determines the region covered by the BIAS CONTROL. The AC VOLTAGE CONTROL may now be slowly advanced, being careful to keep the trace within the predetermined limits. A family of curves can be obtained by rotating the UNIT STEPS switch, If it is desired to obtain a permanent record of the family, this can readily be obtained by a multiple exposure; one exposure for each of the curves plus one for the axes. A Polaroid Land camera is very convenient for the purpose.

TRANSFER CHARACTERISTICS - Emitter voltage vs.collector current.

This circuit (see Fig. 3) is virtually the same as that used for taking collector characteristics. The ordinate voltage, however, is measured at the emitter rather than the collector. The slope of this curve is the base resistance which is generally referred to as R_{12}.

Operation

Move FUNCTION switch to TRANS position and proceed as for observing collector characteristics. The vertical gain control of the cathode ray oscilloscope will generally have to be increased for this measurement, due to the relatively small voltage across the emitter.

EMITTER CHARACTERISTICS - Emitter voltage vs. emitter current.

The simplified schematic is shown in Fig. 4. The sweep voltage is applied to the emitter, and the collector is held at a constant voltage by means of an 80 μf capacitor. The slope of this curve is sometimes referred to as h_{11} and is equal to the input resistance of the transistor with the collector short circuited. The measurement also shows immediately the short-circuit stability of a point contact transistor. A unit which is short-circuit unstable will exhibit a negative slope over some portion of this curve.

Operation

With the A-C VOLTAGE CONTROL and D-C VOLTAGE CONTROL set to zero, move the FUNCTION switch to the EMIT position. Adjust the D—C VOLTAGE CONTROL to the desired collector voltage which is read

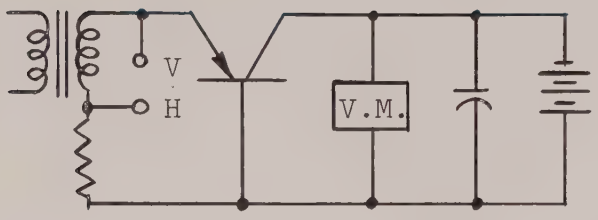

Figure 4

directly from the panel meter on any of the two scales. Slowly advance the A-C VOLTAGE CONTROL until the desired sweep amplitude is obtained. It is important to note that the display will be either in the first or third quadrants and rather high gain is necessary to observe the emitter voltage in the forward direction. The back voltage, which is generally of little interest, will be very large by comparison and is limited at about 20 volts by a diode circuit (which causes a break in the back voltage characteristic). A family of curves may be obtained by adjusting the collector voltage in increments.

ALPHA CHARACTERISTICS -
Alpha vs. emitter current

The α characteristic provides, in one display, a great deal of information. For point contact transistors, it immediately shows up any instabilities and measures α at any emitter current up to 10 ma. and any collector voltage up to 100 volts. The speed of α rise at small currents can also be correlated with the switching speed of the transistor. For junctions, it provides an accurate, 1%, measurement of the current gain. As with the other measurements, the sweep is 60 $\sim$, swept in both directions, and the signal frequency is 50 kc. Experience has shown that nearly all transistors show a flat response up to and beyond this frequency when the grounded base connection is used.

Fig. 5 shows the operation of the circuit. The emitter sweep current is obtained from a 1:1 isolation transformer in series with a set of fixed resistors (DECADE STEPS). The 50 kc signal is superimposed on this current from a 100 K-ohm source impedance. The output is taken from across a 100-Ω precision potentiometer in the collector circuit. It is then amplified in a band-pass amplifier and rectified to give the pattern on the oscilloscope. For calibration, the double pole switch is moved to the down position, and the 50-kc signal is now connected to the arm of the pot. through the same 100 K resistor. This provides a maximum scale of unity for junction transistors. For point contact transistors, the 10 K resistor is switched in and the maximum reading is 10. The H deflection is taken from a compensated voltage divider which can be adjusted to eliminate hysteresis due to phase shifts in the external equipment.

Operation

Set the FUNCTION switch to the ALPHA position and adjust the D-C VOLTAGE CONTROL to obtain the desired collector voltage as observed on the panel meter. Note that the actual voltage on the transistor will differ from the meter reading by the voltage drop in the 100-Ω collector load. Next adjust the DECADE STEPS switch to the appropriate emitter sweep amplitude which is 10 times the indicated values. For example, if

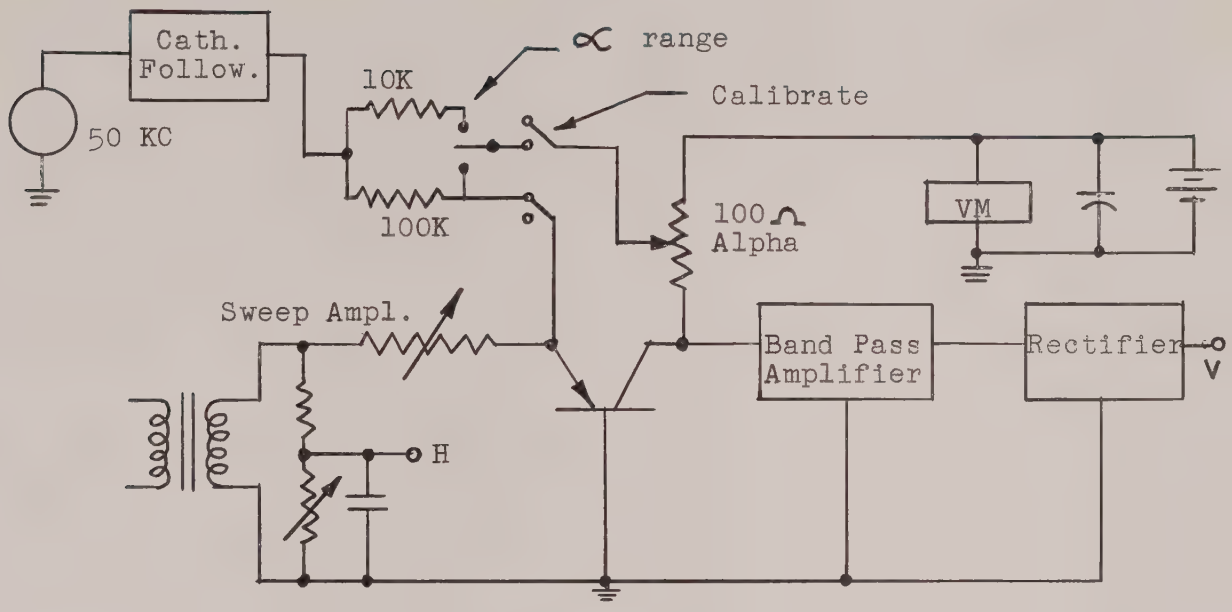

Figure 5

a maximum sweep of 2 ma. is required, set the switch to the 0.2 position. The emitter current will then sweep out to 2 ma. In order to correct for differences in phase, the phase adjust control at the back should be adjusted to eliminate hysteresis.

To measure alpha at a particular value of emitter current, move the trace horizontally so that this current corresponds to a mark on the reticule. Switch the ALPHA RANGE switch to the "1" position when measuring a junction transistor, or "10" when measuring point contact transistors. (Transistors having a current gain greater than 10 can also be measured as explained below.) Now press the ALPHA CAL lever switch which will cause the unmodulated 50 kc carrier to appear on the oscilloscope.

Adjust the vertical amplitude of this trace by varying the ALPHA potentiometer until it is exactly equal to the amplitude of the trace at the predetermined emitter current. The lever switch can be depressed several times in rapid succession in order to obtain an accurate reading and eliminate any drift effects in the oscilloscope.

To obtain the zero emitter current point, of the ∝ trace, reduce the oscilloscope horizontal gain to zero. This point or line corresponds to zero emitter current.

The amplitude of the ∝ traces may vary somewhat as the sweep amplitude (DECADE STEPS) is varied, but this is not an instrument error. In order to maintain optimum signal to noise ratio, the probe current which is fed to the emitter is varied with the sweep and the amplifier gain is roughly

tracked to maintain a reasonably constant image size.

To measure α greater than 10, adjust the oscilloscope vertical gain so that the α waveform is an integral number of units high and adjust the ALPHA potentiometer to a fraction of this amplitude. The current gain will be the reading on the potentiometer multiplied by the reciprocal of this fraction.

At signal levels corresponding to alphas of less than 0.5, the rectifiers do not operate linearly. This does not affect the accuracy of the calibration since the amplitudes of both the signal and calibration are equal during calibration. When measuring current gains greater than 10, the nonlinearity is negligible and although the signal and calibration trace are not equal in amplitude, there is virtually no error from this cause.

COLLECTOR CHARACTERISTIC - (grounded emitter) Collector voltage vs. collector current

This set of curves is principally for use with junction transistors where the high collector resistance makes it difficult to read slopes. The circuit is similar to that used in the grounded base measurement (see Fig. 6), but only 20 μa steps are provided for, plus the variable position.

Operation

Move the FUNCTION switch to the GND EMIT position and return the AC VOLTAGE CONTROL to zero. Rotate the DECADE STEPS selector to the extreme counter clockwise position, -.02 and slowly advance

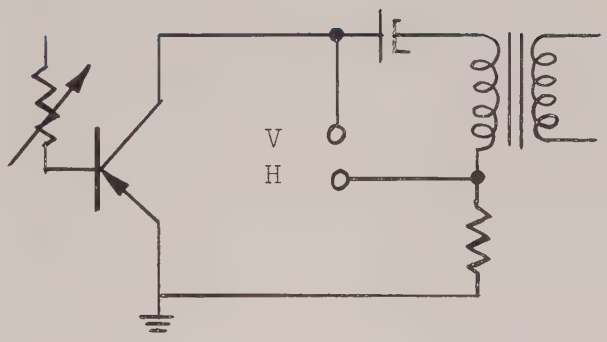

Figure 6

the AC VOLTAGE CONTROL until a suitable sweep length appears on the oscilloscope screen. A family of curves may now be taken by rotating the UNIT STEPS switch. Intermediate values of I_b may be chosen by using the VAR position and varying the BIAS CONTROL.

Internal Adjustments

There are several additional adjustments which are available on the chassis. These are preset at the factory and normally require no attention. However, when replacing vacuum tubes or other major components, these adjustments should be checked.

1. Axis Calibration

Two screw driver adjust potentiometers are located together on the top of the chassis. These should be adjusted with the front panel calibrating switches in the "10" position and the calibrating potentiometers in the maximum clockwise position. The trace on the oscilloscope is then compared with a 10 volt d-c source and the chassis adjustments made until the trace lengths are equal.

2. Alpha Calibration

A third control is located on the top of the chassis and is for the purpose of adjusting the alpha calibration in the "10" position. No adjustments are required for the "1" position. The procedure for making this adjustment is simply to compare an alpha setting of unity in the "10" position with the unity setting in the "1" position as the standard.

SPECIFICATIONS

ALPHA CHARACTERISTIC (α vs. i_e)

Alpha Range	0-1 0-10
Sweep Length	0.2 ma 0.5 ma 2.0 ma 5.0 ma 10.0 ma
Collector Voltage	continuously variable 0-100 volts

COLLECTOR CHARACTERISTIC (e_c vs. i_c) grounded emitter

Base Current	10 equal incr.
Size of Incr.	20 μa
(Interpolation available between increments)	
Collector Voltage	continuously variable 0-100 volts

COLLECTOR CHARACTERISTIC (e_c vs. i_c) grounded base

Emitter Current	10 equal incr.
Size of Incr.	20 μa 50 μa 200 μa 500 μa 1000 μa
(Interpolation available between increments)	

TRANSFER CHARACTERISTIC

Emitter Current	10 equal incr.
	20 μa 50 μa 200 μa 500 μa 1000 μa
(Interpolation available between increments)	
Collector Voltage	continuously variable 1-100 volts

TRANSISTOR TYPES MEASURED

Point contact	type N or P
Junction	type NPN or PNP

CALIBRATION

Available in both axes - calibrated dial indication 0-1, 10, 100 volts

OUTPUT IMPEDANCE

Low-cathode follower in both outputs. No shielding required.

METER

Voltmeter to measure collector volts 10, 100.

GENERAL

Power Supply
105-125 volts - 60 cps - 80 watts

Weight
35 lbs.

Dimensions
Hardwood Cabinet 20" x 13-1/2" x 10"

Standard Size Panel 19" x 12-1/4"

Equipment Supplied
Transistor plug-in assembly. Contains two sockets wired in parallel to accept point contact and junction transistors. Additional sockets easily added.

Accessories
D-c oscilloscope. Not supplied.

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